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Distribution and abundance of a threatened stem-boring moth, *Houdinia flexilissima*, (Lepidoptera: Batrachedridae) in New Zealand peat bogs

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Abstract. The threatened stem-boring moth, *Houdinia flexilissima* (Lepidoptera: Batrachedridae), is known only from one host plant, *Sporadanthus ferrugineus*, which is also threatened. *Sporadanthus ferrugineus* is known from three isolated peat bogs in the Waikato region, New Zealand (Kopuatai, Torehape and Moanatuatua) and four other wetlands following translocation (Lake Komakorau, Lake Serpentine and Waiwhakareke) or restoration (Torehape peat mine). The distribution and abundance of *H. flexilissima* was assessed using a new monitoring technique which involved counting, harvesting and dissecting the *Sporadanthus* stems for the presence of larvae. The moth was found in natural, translocated and restored wetlands. *Houdinia flexilissima* appears to be able to survive wherever *S. ferrugineus* plants are present, and is most common in stems 2.0–4.5 mm in diameter. It has established in small translocated populations (≤270 m^2) from larvae contained within stems of the original translocated *Sporadanthus* plants, and at the restoration site by dispersal from adjacent natural populations 800 metres away. From a conservation perspective, the pattern of population establishment in the absence of additional interventions is encouraging for the long-term persistence of *H. flexilissima*. Herbivory rate, larval density and larval size varied with the time since translocation, age of the restoration plantings and size of the natural wetlands. The sampling method used could be applied to ecological studies investigating other stem-boring Lepidoptera taxa.

Keywords: conservation, threatened taxa, wetland, sampling method.

Introduction

There has been a dramatic worldwide decline in the extent and health of wetlands (Keddy, 2000). Globally, peatlands are the most widespread of all wetland types, covering over four million km^2 (3%) of the planet's land surface, and in particular comprise a significant proportion of the boreal and subarctic regions in the northern hemisphere. In contrast, Australasian peatlands generally occupy a small proportional area, are restricted in their distribution and very few remain in their natural state (Whinam *et al.*, 2003). For example, more than 75% of the original area of restiad peat bogs (dominated by species in the angiosperm family Restionaceae) in northern New Zealand have been converted to agricultural use. Such New Zealand restiad bogs are distinct from northern hemisphere *Sphagnum* bogs because their vegetation is characterised by two endemic restiad species: *Sporadanthus ferrugineus* and *Empodisma robustum* (Wagstaff & Clarkson, 2012), the remains of which commonly compose the bulk of peat deposits (Thompson *et al.*, 1999). Restiad bogs dominated by *Sporadanthus ferrugineus* originally covered more than 100,000 ha of northern New Zealand (de Lange *et al.*, 1999), where they formed extensive domes with peat depths up to 12 m. These bogs now represent one of New Zealand's most threatened ecosystems because of widespread drainage and conversion to pasture during the last 150 years (de Lange *et al.*, 1999). As with wetlands in general, peat bogs have multiple values, including filtering sediments, sequestering carbon, moderating the effects of floods, regulating water quality, and providing habitat for indigenous flora and fauna (Costanza *et al.*, 1997; Watts & Patrick, 2001).

There has been a paucity of entomological research associated with New Zealand peat bogs although their invertebrate fauna is known to

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be relatively depauperate and includes some specialized species (Watts & Patrick, 2001). For example, in 2003 a highly peculiar lepidopteran larva was discovered feeding in the narrow stems of *Sporadanthus ferrugineus*, at Torehape bog, and was identified as a new genus and species of moth (*Houdinia flexilissima*: Batrachedridae; Hoare *et al.*, 2006). The only known host is *S. ferrugineus,* an endemic dioecious perennial restiad with smooth wiry culms (stems) up to 3 m high that form dense swards (de Lange *et al.*, 1999). However, the extent of peatland loss resulted in *S. ferrugineus* being listed as a threatened species that occurs naturally in only three Waikato wetlands (Kopuatai, Torehape and Moanatuatua; Fig. 1). Larval damage present on historical herbarium specimens (Allan Herbarium, Landcare Research; Waikato University) suggests that *H. flexilissima* was formerly distributed throughout the Waikato, wherever *S. ferrugineus* occurred (Hoare *et al.*, 2006). To increase the number of populations *S. ferrugineus* and to 'recreate' this rare wetland type, three new populations were established at Lake Serpentine, Lake Komakorau, and Waiwhakareke between 2006 and 2008 (Peters, 2007; Fig. 1).

Houdinia flexilissima appears to have a 2-year life cycle, based on the presence of earlier instar larvae in stems at the time of adult emergence. Adults lay eggs in late spring (October–November) near the base of a scale-like leaf of *S. ferrugineus.* The larvae mine into the green photosynthetic layer of the stem leaving star-shaped excavation tunnels extending up the stem (Fig. 2). The larva of *H. flexilissima* represents one of the most modified (and certainly one of the thinnest) larvae of all Lepidoptera (Hoare *et al.*, 2006) and appears specialized for feeding on *S. ferrugineus.* Later instars burrow in the deeper tissues of the culm, showing no external sign of their presence. Although more than one egg and excavation tunnel are commonly observed on a single stem, only one larva has ever been found inside each stem. Despite this damage, the vigour of the plant seems unaffected (Hoare *et al.*, 2006). Pupation occurs in the internodes of the culms in a chamber lined with fine whitish silk, the exit-hole usually being just above a leaf. Adults hatch over spring (October–December). The behaviour of the pharate adult at eclosion is a mystery, because no pupal remains were found in or protruding from stems from which adults had emerged; however, most emergence holes are surrounded by a rim of shed scales. When reared, adults rested on the brownish leaves at the internodes of the host culms and in this position were well camouflaged and extremely hard to detect (Hoare *et al.*, 2006).

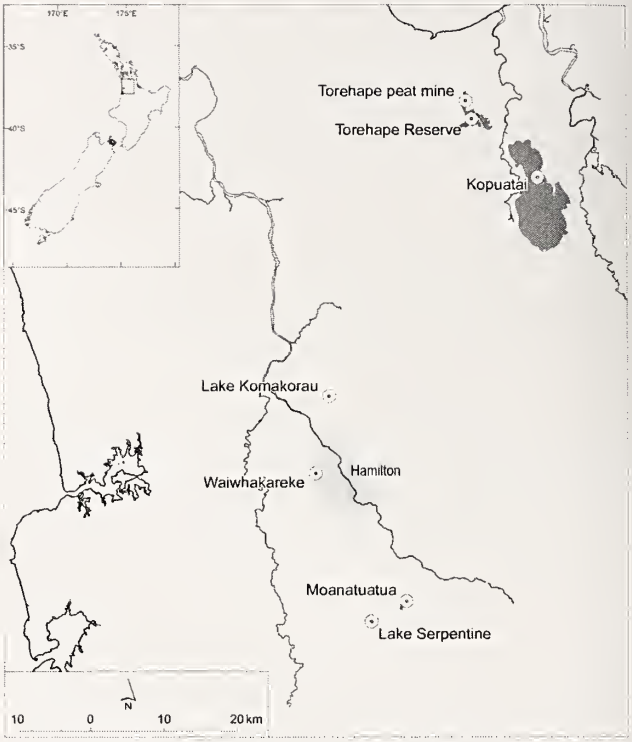

Figure 1. Locations of H. flexilissima populations in the Waikato, New Zealand. There are three naturally occurring populations at Kopuatai, Moanatuatua and Torehape Reserve. In addition, there are translocated populations at Lake Komakorau, Lake Serpentine, Waiwhakareke, and on the naturally regenerated at Torehape peat mine.

The larvae of *H. flexilissima* are totally dependent on *S. ferrugineus* for shelter and food. For this reason, Stringer *et al.* (2012) recently classified *H. flexilissima* as threatened and also placed it within the 'relict' category as the moth is found naturally at only three locations within the Waikato. Despite the threatened status of *H. flexilissima*, little is known about its distribution, abundance or its autecology. The objective of this study was to assess the distribution and abundance of *H. flexilissima* in the three naturally occurring *Sporadanthus*-dominated peat bogs (Kopuatai, Torehape and Moanatuatua) and at the translocated and restored populations of *S. ferrugineus.* The study was designed to determine some of the habitat preferences of *H. flexilissima* and included an investigation into whether the abundance of *H. flexilissima* was correlated with plant nutrients. Finally, this study was also designed to test the suitability of a new sampling method for monitoring the species.

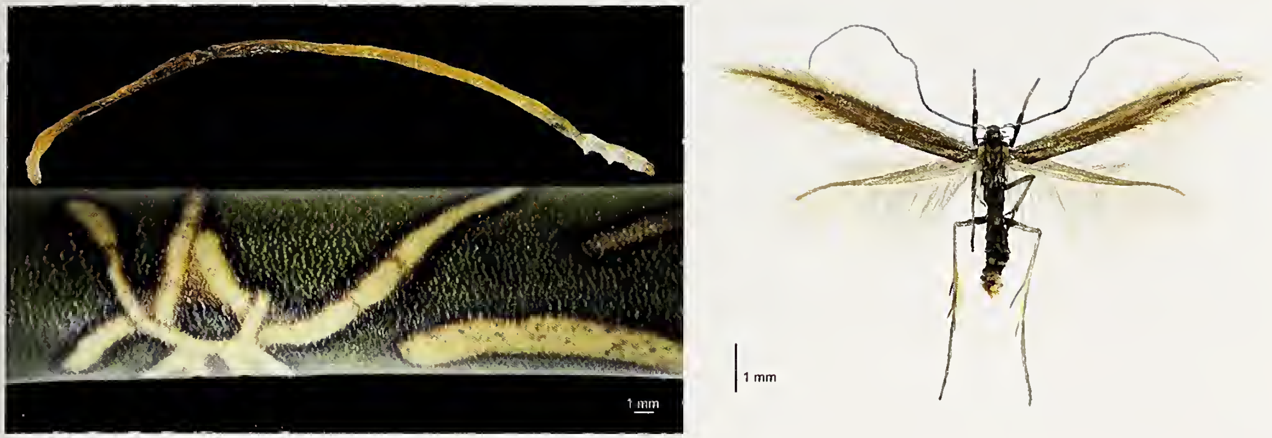

Figure 2. Larva, early excavation tunnel, and adult male of *Houdinia flexilissima* (Lepidoptera: Batrachedridae). The larvae of *H. flexilissima*, colloquially named 'Fred the Thread', feed in the green photosynthetic layer of *Sporadanthus ferrugineus* stems, leaving these characteristic tunnels. The adults are small delicate moths that are found in Waikato peat bogs between October and December.

Methods

Study sites

Three naturally occurring peat bogs, Kopuatai (10201 ha), Torehape (350 ha) and Moanatuatua (114 ha), in the Waikato contain representative examples of the original restiad raised bog ecosystem. This typically comprises an upper tier of *S. ferrugineus* up to 2.5 m in height, which overtops a dense lower layer of intertwining wiry-stemmed *Empodisma*. Other common species include *Epacris pauciflora*, *Leptospermum scoparium* and *Baumea teretifolia*.

Mining for horticultural peat occurs at Torehape, but the operators are required to restore the original peat bog vegetation after the permitted depth of peat has been removed (usually 1 metre). The area of the peat mine is 150 ha, of which only 40 ha remain unmodified. Current recommended practice for restoration of mined areas involves the creation of raised 'habitat islands' (5 m diameter and 30 cm high) of processed peat approximately 30 m apart. These were seeded with the shrub *Leptospermum scoparium* (Myrtaceae), an early successional plant in peat bogs, which is eventually out-competed by *S. ferrugineus* (Clarkson, 2002). The islands reached 100% vegetation cover in 2 years, with late successional peat bog plants beginning to establish within this timeframe (Schipper *et al.*, 2002). All the islands within a 'lane' were of similar age and each 'lane' was approximately 45 m wide and 950 m long.

Three new populations of *S. ferrugineus* were established at Lake Serpentine, Lake Komakorau and Waiwhakareke between 2006 and 2008 (Peters, 2007) by transplanting plants of between 0.5 and 1.5 m tall from Torehape peat mine to each site to achieve planting densities of approximately 0.75 plants per m^2 (Peters, 2007). At all the translocated sites, the existing vegetation (exotic pasture grasses and weeds) was removed and the upper soil layers excavated to a depth of 30 cm to form a shallow depression that was then filled with peat to a depth of *c.* 30 cm. Translocated plants were removed from Torehape peat mine and immediately taken to the translocated site. Areas planted were 20 × 9 m (180 m^2) at Lake Komakorau, 30 × 9 m (270 m^2) at Lake Serpentine and 22 × 12 m (264 m^2) at Waiwhakareke. It was assumed that *H. flexilissima* would also be translocated within the *S. ferrugineus* plants (Peters, 2007).

Monitoring *H. flexilissima* in *Sporadanthus*-dominated peat bogs in the Waikato

At Kopuatai, Torehape and Moanatuatua, paired plots were established 10 m apart on opposite sides along a transect in vegetation dominated by *S. ferrugineus* (>75% cover) and at varying distances from the edge of the wetland (Table 1). Two transects at Kopuatai (Tee Canal and Northern transect) and one transect each at Moanatuatua and Torehape were established (Table 1).

At Torehape peat mine, three mined 'lanes' that had been restored 11, 13 and 15 years previously were chosen for study. The study 'lanes' were approximately 150 m apart, separated by drains and other 'lanes' that had been restored with peat islands of varying ages.

Table 1. Location of *H. flexilissima* surveys in Waikato wetlands.

Wetland	Transect location	Number of plots (n)	Distance of plots from wetland edge (m)
Kopuatai Wetland Reserve	Transect 1: Tee Canal	8	35, 70, 105, and 140
Kopuatai Wetland Reserve	Transect 2: Northern transect	6	500, 1000, and 1500
Moanatuatua Peat Scientific Reserve	Transect 1	10	5, 50, 100, 200, and 300
Torehape Wetland Management Reserve	Transect 1	6	25, 70, and 105

Table 2. GLM parameters for proportions of stems damaged per plot, number of larva per metre of stem and larval size (mm) of *H. flexilissima.*

Wetland	Parameter	F	P
Proportion of stems damaged per plot	Wetland×Distance	0.61	0.544
	Wetland	139.63	<0.001
	Distance	8.91	0.003
Number of larva per metre of stem	Wetland×Distance	0.25	0.779
	Wetland	112.15	<0.001
	Distance	19.69	<0.001
Larval size	Wetland×Distance	0.43	0.655
	Wetland	70.55	<0.001
	Distance	23.09	<0.001

At approximately 600 m from the adjacent wetland, two islands spaced approximately 20 m apart were surveyed for presence of *H. flexilissima* on naturally regenerated *S. ferrugineus* plants on these islands. One plot on each island was placed in vegetation dominated by *S. ferrugineus* (>75% cover).

At the translocated *S. ferrugineus* populations at Lake Serpentine, Lake Komakorau and Waiwhakareke, one plot was placed approximately 2 m inside each of the four corners of area of translocated *S. ferrugineus* populations.

Surveys were carried out from 25 March to 23 April 2013. At each sampling point, a GPS position was recorded then a 33 cm diameter circular frame (0.086 m^2) used to define the plot was placed over the *S. ferrugineus*, and 20 stems were randomly chosen from within this plot. Each stem was sampled by removing a piece 60 cm long (measured from the first internode directly below the seedhead) and collecting it in a paper bag (800 × 400 mm) for later examination in the laboratory. In the laboratory, stems were searched for the presence/absence of *H. flexilissima* and dissected to count the larvae of *H. flexilissima*. The number of larvae (alive, dead, or presence of frass) and larval size were recorded for each stem. The presence of external damage from stem-mining was used to calculate the proportion of stems damaged per plot. The width of each *S. ferrugineus* stem (mm) was recorded at 60 cm below the seedhead and the lowest and highest *H. flexilissima* excavation tunnel relative to the seedhead were recorded.

Plant nutrients in *S. ferrugineus* stems

Plant nutrients have been shown to decrease from the edge to the centre of Waikato peat bogs (Clarkson *et al.*, 2004) and we were interested in investigating whether *H. flexilissima* abundance was correlated with plant nutrients. At each sampling point, a subsample of six *S. ferrugineus* stems each measuring 4 cm in length was analysed for nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, sodium, iron, manganese, zinc, copper, and boron. Means ± 95% CI were calculated for each plant nutrient at each wetland so that differences (P = 0.05) between wetlands were apparent by inspection.

Data analysis

The data from the naturally occurring populations of *H. flexilissima* (Kopuatai, Moanatuatua and Torehape) were analysed using a general linear model (GLM), testing the fixed treatment effects of wetland and distance from the wetland edge. Models with number of larvae per metre of stems and average larval size as response variables assumed a normal error distribution, models testing the proportion of stems damaged per plot used a binomial error distribution with a $\log_e$ (x+1) link function, and the model testing the proportion of stems damaged per plot used a binomial error distribution and a logit link function. An unpaired *t* test was used to compare the herbivory rates, density, and average larval size of *H. flexilissima* in naturally occurring *S. ferrugineus* areas with those in translocated areas. The relationship between the proportions of stems damaged per plot and the number of larvae per metre of stem was analysed using a simple linear regression. All statistical analyses were performed using GenStat version 8.1.0.152 (VSN International, 2012).

Results

Distribution and abundance of *H. flexilissima* in *Sporadanthus*-dominated peat bogs in the Waikato

A total length of 600 m of *S. ferrugineus* stem from 50 plots was examined for the presence of *H. flexilissima*.

All the variables measured showed no significant interaction between wetland and distance from the wetland edge (Table 2). However, this is probably due to lower rates of herbivory, larval densities and larval size collected from Kopuatai (particularly at Tee Canal) compared with Moanatuatua and Torehape, where the data showed similar trends (Figs 3A, 4A, and 5A). The treatment effects of wetland and distance from wetland edge were both significant for the variables measured (Table 2). Moanatuatua and Torehape had similar intercepts and slopes whereas those for Kopuatai differed (Table 2, Figs 3A, 4A, and 5A). At Kopuatai, Moanatuatua and Torehape, herbivory rates, larval density, and larval size increased significantly with distance into the wetland (Table 2, Figs 3A, 4A, and 5A). The proportions of stems damaged per plot and larval densities were much lower, and smaller larvae were found in *S. ferrugineus* stems at Tee Canal in Kopuatai (Figs 3A, 4A, and 5A).

Overall, the herbivory rates, larval density and larval size of *H. flexilissima* did not differ between the naturally occurring and translocated or restored populations (proportions of stems damaged, t = 0.523, df = 1, 48, P = 0.603; larval density, t = 0.432, df = 1, 48, P = 0.667; and larval size, t = 0.457, df = 1, 48, P = 0.568) of *S. ferrugineus*. There was some variation in herbivory rates, larval density and larval size of *H. flexilissima* at the translocated sites but this fell within the range observed in the naturally occurring populations. Herbivory rates, larval density and larval size of *H. flexilissima* were all similar at Lake Komakorau, Lake Serpentine, and Torehape peat mine whereas these were marginally lower at Waiwhakareke, the youngest population translocated 5 years ago (Figs 3B, 4B, and 5B).

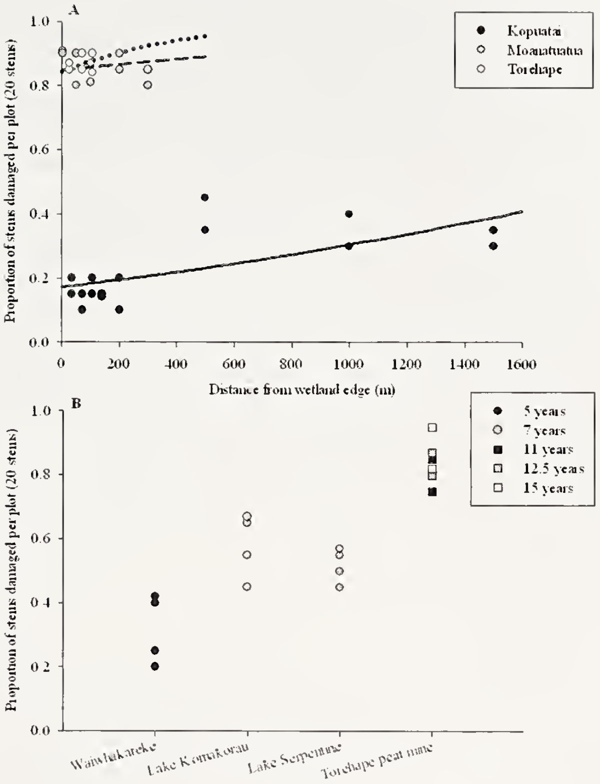

Figure 3. Proportion of *S. ferrugineus* stems damaged by *H. flexilissima*. **A)** Naturally occurring populations at Kopuatai, Moanatuatua and Torehape; **B)** Other locations, including translocated and restored populations. Equations of the fitted lines are Kopuatai (solid line) = –1.585+0.000777x; Moanatuatua (medium dashed) = 1.721+0.000745x and Torehape (dotted line) = 1.689+0.0027x. Coincident data have been offset for clarity.

The proportions of stems damaged per plot showed a significant positive relationship with the number of larvae found per metre of *S. ferrugineus* stem ($F_{1,49}$=332.37, P<0.0001; Fig. 6). Kopuatai had a lower proportion of stems damaged per plot and number of larvae found per metre of stem compared with Moanatuatua and Torehape (Fig. 6). Values for the translocated populations and restored population of *S. ferrugineus* at Torehape peat mine fell within the values for Kopuatai (low) and Moanatuatua-Torehape (high) (Fig. 6).

Houdinia flexilissima was found in stems ranging from 1.62 to 4.46 mm in diameter and the average stem width for *S. ferrugineus* stems at 60 cm below the seedhead was similar across all the wetlands surveyed (Fig. 7). In addition, the stem width where the lowest and the highest excavation tunnel of *H. flexilissima* were found was similar in all wetlands (Fig. 7). The average stem width where the lowest excavation tunnel was found was consistently larger than the stem width were the highest excavation tunnel was found (Fig. 7).

Plant nutrients in *S. ferrugineus* stems

No differences in the nutrient concentrations of *S. ferrugineus* stems were detected between the wetlands sampled except for manganese and iron. Manganese had a significantly higher concentration at the translocated populations at Waiwhakareke, Lake Komakorau and Lake Serpentine than elsewhere (Fig. 8) and iron had a significantly higher concentration at Tee Canal in Kopuatai than elsewhere (Fig. 9).

Discussion

Houdinia flexilissima was found in all the peat bogs where *S. ferrugineus* occurs in the Waikato but it is particularly encouraging, from a conservation perspective, that this moth has established, and populations appear to be viable at the translocated *S. ferrugineus* populations at Lake Komakorau, Lake Serpentine, Waiwhakareke, and where *S. ferrugineus* plants have naturally regenerated at the restored Torehape peat mine. A review by Schultz *et al.* (2008), found that most conservation strategies for threatened butterflies recommended reintroduction (n = 34) which has been attempted for 21 British species and only 5 American. Documentation of reintroduction techniques and whether the translocations were successful was limited. The present study confirmed that no additional intervention is required for translocating *H. flexilissima* other than translocating *S. ferrugineus* plants containing *H. flexilissima* larvae. This moth was translocated to Waiwhakareke only 5 years ago and so is probably still in the establishment phase and we suggest this might be why the herbivory rates and larval density were marginally lower and

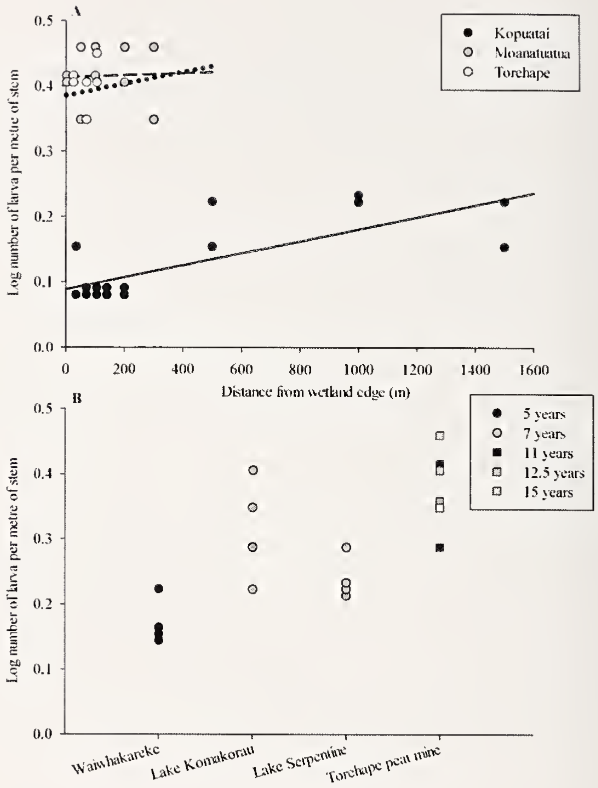

Figure 4. Number of *H. flexilissima* larvae per metre of *S. ferrugineus* stems. **A)** Naturally occurring populations at Kopuatai, Moanatuatua and Torehape; **B)** Other locations including translocated and restored populations. Equations of the fitted lines are Kopuatai = 0.0886+0.0000926x, Moanatuatua = 0.4132+0.000016x, and Torehape = 0.3855+0.0000907x. Coincident data have been offset for clarity.

larvae were smaller than in the other two translocated populations which were transferred 2 years earlier. It is expected that the herbivory rates, larval density, and size of *H. flexilissima* will be similar to the other translocated populations within the next few years.

We can offer no explanation as to why herbivory rates, larval density, and larval size increased significantly with distance into the wetland in the larger areas (> 350 ha) of naturally occurring populations of *S. ferrugineus* but herbivory rate and larval density appear not to be related to dispersal ability of the moth as evidenced by the experimental work of Watts & Didham (2006). They found that wetland habitat loss at the Torehape peat mine caused an almost complete failure of *H. flexilissima* to colonise potted *S. ferrugineus* plants at distances of greater than 400 m from undisturbed wetland and that the number of eggs and larvae in *S. ferrugineus*, and the proportion of *S. ferrugineus* stems damaged, all decreased logarithmically with increasing distance from the intact wetland habitat, and this was presumably due to limitation in the dispersal ability of the herbivore. They also found that average larval size decreased logarithmically with increasing distance from the intact wetland habitat but offered no explanation for this. Yet, recolonisation was surprisingly rapid following experimental habitat restoration. Three years after restoration there was no significant difference in the frequency of oviposition in host plants at differing distance of isolation from the wetland, and 6 years after restoration, the degree of herbivory damage had returned to pre-habitat loss levels (Watts & Didham, 2006).

The largest area of *S. ferrugineus* in the Waikato occurs at Kopuatai Wetland Reserve (10, 201 ha). However, the herbivory rates, density of larvae, and larval size of *H. flexilissima* were significantly lower here than at the other wetland sites. One possible factor may be the influence of plant size which could make larger plants more visible, emit more volatiles that attract adult moths or provide more resources for oviposition (thus increasing colonisation rate). Furthermore, it is widely accepted that larger host-plant patches will have a higher probability of establishment success and a lower risk of population extinction than smaller host-plant patches, for any given colonisation rate. Plant size was not measured in the study but it is unlikely that the plants at Kopuatai were smaller than at the other wetlands.

One possible reason why herbivory rates and density of larvae were lower, and larvae were smaller at Kopuatai could be related to nutrient levels within the *S. ferrugineus* plants but we detected no differences between the wetlands except for manganese which was higher in the translocated locations than elsewhere and for iron that was higher at Transect 1 (Tee Canal) in Kopuatai than elsewhere. It is unknown why these differences are present although the presence of a nearby freshwater spring at Tee Canal may relate to the higher concentrations of iron there but we did not sample the water. It is also unknown what effect these differences in concentration might have on *H. flexilissima*. The only information relating to nutrient levels for manganese or iron and Lepidoptera was published by Phelan *et al.* (1995) who found oviposition rates of the European corn borer, a pyraloid moth (*Ostrinia nubilalis*), were positively correlated with iron. However, interactions between minerals, other nutrients and ecological factors may be variable and be more important than single measures but remain unknown.

The proportion of stems damaged per plot showed a positive relationship with the number of larvae per

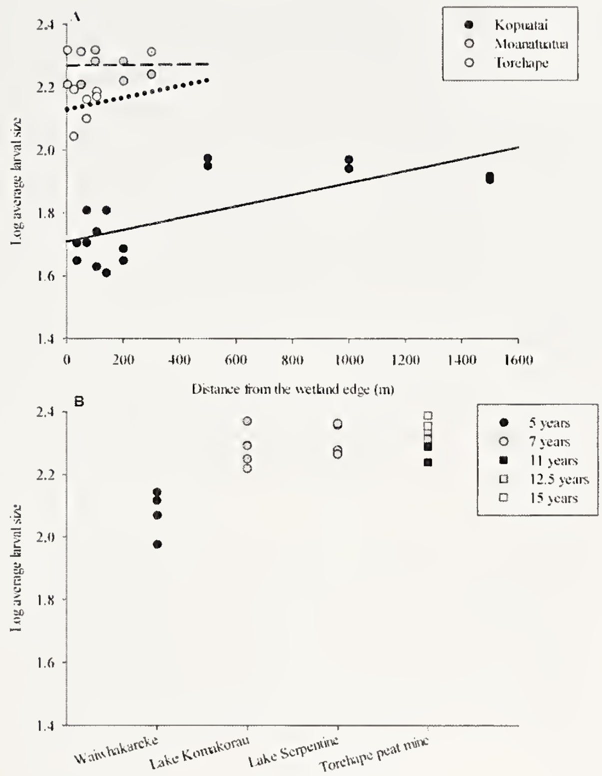

Figure 5. Average larval size (mm) of *H. flexilissima*. **A)** Naturally occurring populations at Kopuatai, Moanatuatua and Torehape; **B)** Other locations including translocated and restored populations. Equations of the fitted lines are Kopuatai = 1.707+0.000190x, Moanatuatua = 2.268+0.0000095x, and Torehape = 2.129+0.000186x. Coincident data have been offset for clarity.

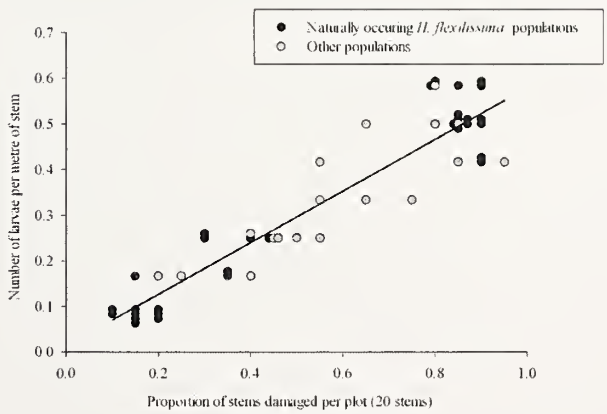

Figure 6. Relationship between the proportions of stems damaged per plot and the number of larvae per metre of stem. Regression equation is y = 0.0136+0.565x. Coincident data have been offset for clarity.

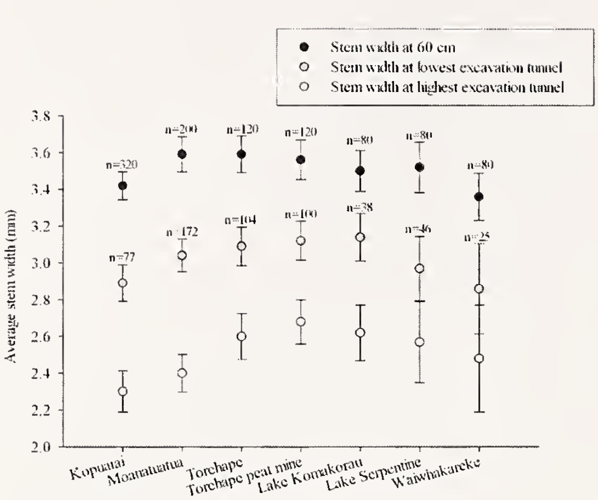

Figure 7. Average width of *S. ferrugineus* stems measured and stem width at highest and lowest excavation tunnel of *H. flexilissima.* Means ± 95% CI are presented so that any differences (P = 0.05) between wetlands are apparent by inspection. Upper n = number of stems measured at 60 cm at each wetland, lower n = number of stems measured at lowest/highest excavation tunnel at each wetland.

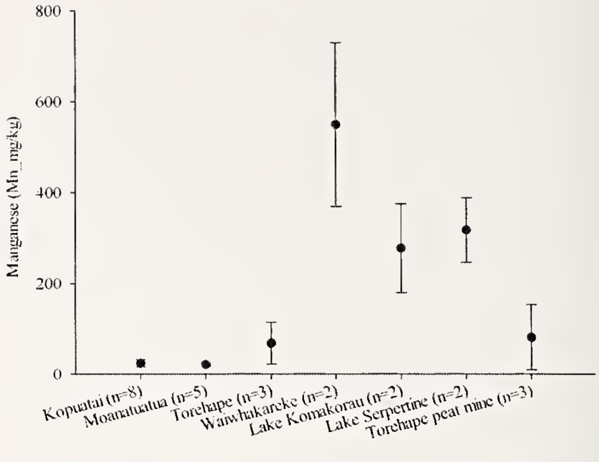

Figure 8. Concentrations of manganese (mean ± 95% CI) found in *S. ferrugineus* stems collected from Waikato wetlands.

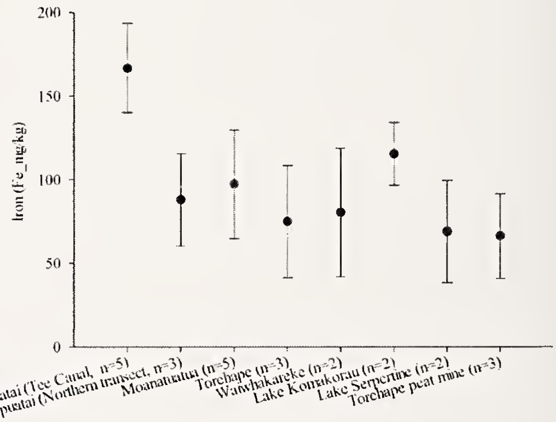

Figure 9. Concentrations of iron (mean ± 95% CI) found in *S. ferrugineus* stems collected from Waikato wetlands.

metre of stem demonstrating that the proportion of stems damaged can be used as a surrogate for the number of larvae per metre of stem as it provides similar information on the overall abundance of *H. flexilissima* present in a *S. ferrugineus* plant. Stems, therefore, do not need to be harvested from the *S. ferrugineus* plant in the peat bogs and dissected to record the number of larvae so using the proportion of stems damaged avoids the killing of larvae of a threatened species. Our procedure whereby 1000 stems of *S. ferrugineus* were harvested resulted in the deaths of 198 *H. flexilissima* larvae, because they cannot survive once removed from the *S. ferrugineus* stems.

From this study, *H. flexilissima* can survive wherever there are *S. ferrugineus* plants. The moth appears to have established and be thriving even in the small (≤270 m^2), translocated populations. Our results suggest that *H. flexilissima* appears to have a preference for *S. ferrugineus* stems between approximately 2.0 and 4.5 mm in diameter based on the amount of herbivory that stems in this size range experience. Adult *H. flexilissima* moths appear to target this size of stem to lay their eggs, and we speculate that it may be easier for first instar larvae to mine into the green photosynthetic layer of smaller, younger stems compared with older stems which are more rigid.

One of the greatest possible threats facing Waikato peat bogs is weed invasion, particularly in areas of fertile sedgelands and rush lands surrounding the nutrient-poor raised bogs dominated by *S. ferrugineus*. For example, willow (*Salix* spp.) and *Osmunda regalis* have become increasing components of the sedge-dominated vegetation at the higher-nutrient margins of Waikato peat bogs such as Kopuatai. A recent study in Waikato wetlands indicates that introduced grey willow (*Salix cinerea*) appears to dramatically alter the composition of beetle communities present. However, these communities can be restored to a beetle fauna that is similar to those found within native wetlands through willow removal (Watts *et al.*, 2012).

This sampling method could be applied to ecological studies investigating other stem-boring Lepidoptera associated with other plant species and would be a particularly useful method for other threatened species. In New Zealand, in addition to *H. flexilissima*, there are a number of stem-boring species of Lepidoptera that are restricted to peat bogs. For example, the larvae of *Bactra* sp. (Tortricidae) feed in the stems of *Empodisma minus* and '*Batrachedra*' sp. near *eustola* (Batrachedridae) larvae mine in the stems of *Baumea teretifolia* (Hoare *et al.*, 2006). These are potentially of conservation concern because their distribution, abundance and habitat requirements remain unknown.

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